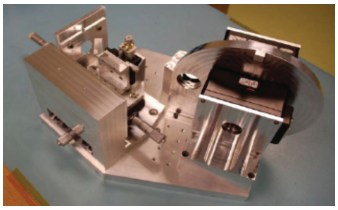
10 Years of ESTO Technology Investments are Enabling the CLARREO Mission, Shaping Future Radiation Budget Measurements

In 2017, NASA plans to launch the first in a series of satellites that will comprise the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission. The CLARREO mission will measure the amount of energy entering and leaving the atmosphere – Earth's radiation budget – more accurately than ever before, providing a reliable benchmark for the climate record going forward and improving climate prediction and modelling.

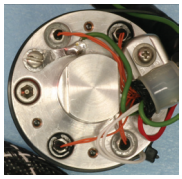
For nearly a decade, carefully managed technology projects built and validated early versions of the instruments and components needed for such a mission. In many ways, the development of these early investments enabled the designation of CLARREO as a mission concept in 2007. What follows are a few of these key technologies, including recent investments focused more specifically for CLARREO mission requirements.

The **Far-Infrared Spectroscopy of the Troposphere (FIRST)** instrument, an early airborne precursor to CLARREO, was demonstrated in 2005 on a high-altitude research balloon (shown left) and provided the first-ever high resolution measurement of the complete infrared emission spectrum of the Earth, including the key far-infrared region from 15 to 100 microns that contains over 50% of Earth's longwave radiation. More recently, FIRST was installed at 17,500 feet atop the Cerro Toco Plateau in Chile as part of the Radiative Heating in Underexplored Bands Campaign - II (RHUBC-II). *[PI: Mlynczak, NASA LaRC, IIP 2001 and 2004]*

The **In-Situ Net FLux within the AtMosphere of the Earth (INFLAME)** project has developed a Fourier Transform Spectrometer to measure upward and downward radiation fluxes simultaneously in the lower atmosphere. INFLAME was successfully demonstrated on a LearJet in 2010 (shown right) and may provide calibration/ validation data for CLARREO. *[PI: Mlynczak, NASA LaRC, IIP 2004]*

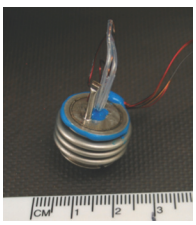


Initiated in 2008, the **Hyperspectral Imager to Meet CLARREO Goals of High Absolute Accuracy and On-Orbit SI Traceability** project seeks to design and construct an advanced, high accuracy Hyperspectral Imager (left), investigate attenuation methods, and validate the solar cross-calibration approach for the CLARREO Mission concept. *[PI: Kopp, Univ. of Colorado, IIP 2007]*



Another recent investment, the **Advanced Accuracy Satellite Instrumentation for the CLARREO Mission** project, seeks to develop and test several key calibration subsystems, such as temperature calibration for the blackbody cavity shown at right, dual absolute radiance interferometers, and an emissivity module. *[PI: Revercomb, Univ. of Wisconsin, IIP 2007]*

Instrument integration activities are ongoing in the **Calibrated Observations of Radiance Spectra from the Atmosphere in the far-InfraRed (CORSAIR)** project. CORSAIR combines a set of technologies central to the CLARREO mission: infrared detector elements, blackbody radiance standards, and robust optical beamsplitters with continuous high efficiency over the full spectral range. *[PI: Mlynczak, NASA LaRC, IIP 2007]*



A new effort began in 2010 to **Demonstrate Thermal Phase Change Cells Onboard the International Space Station (ISS).** The CLARREO mission proposes to use phase change reference standards (melt cells) to recalibrate its on-board temperature sensors; however, these standards have never been flown in space. This project will achieve in-space testing of two melt cell designs, provided by University of Wisconsin and The Space Dynamics Laboratory at Utah State University (shown left), in 2011 onboard the ISS. *[PI: Mlynczak, NASA LaRC]*

For more information on emerging technologies for Earth science, visit the ESTO website at: http://esto.nasa.gov